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## **Radiographically breedspecific morphology and calcifying tendinopathy in the Iliopsoas muscle at the lesser trochanter in Rottweilers, German Shepherd dogs and Bavarian Mountain hounds**

Willmitzer, Florian ; Gumpenberger, Michaela ; Sommerfeld-Stur, Irene ; Mayrhofer, Elisabeth

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## Radiographically Breedspecific Morphology and Calcifying Tendinopathy in the Iliopsoas Muscle at the Lesser Trochanter in Rottweilers, German Shepherd Dogs and Bavarian Mountain Hounds

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### Abstract

The purpose of this retrospective study is to describe the radiographic morphology of the lesser trochanter as well as possible enthesiopathies of the iliopsoas muscle in Rottweilers, German Shepherd Dogs and Bavarian Mountain Hounds. The normal shape of the lesser trochanter appeared radiologically triangular in German Shepherd Dogs and blunt or bump like in Rottweilers and Bavarian Mountain Hounds. Changes indicating an enthesiopathy presented as periosteal blurrings, variation in shape or in isolated bone opacity proximomedial to the lesser trochanter and were categorized into four groups. Three aspects were of special interest: general frequency of radiographic signs of enthesiopathy and potential correlation to sex or to hip dysplasia. In total 736 radiographic studies from Rottweilers (n=311), German Shepherd Dogs (n=133) and Bavarian Mountain Hounds (n=292) have been evaluated. Changes of the lesser trochanter are present in 105 (14.2%) of the radiographic studies. In Rottweilers and Bavarian Mountain Hounds enthesiopathy is significantly correlated to hip dysplasia as dogs classified as "C", "D" and "E" were merged as one group. Regarding gender disposition no correlation was found. Computed tomography (CT) was additionally available in nine dogs and confirmed radiographic findings. The results of this study could be of major interest in the selection process of service, working and sports dogs as enthesiopathies of the iliopsoas muscle occurring in adolescent dogs might act as a life-long weak points, but additional data is needed to evaluate clinical relevance.

**Keywords:** Enthesiopathy; Iliopsoas muscle; Dog

### Introduction

Little attention is usually paid to the lesser trochanter on radiographs of the pelvic region. In few case reports opacities proximomedial of the lesser trochanter are described [1-4]. One author assumed small avulsion fractures, when calcified opacities are projected over the iliopsoas muscle [5]. Another author describes them as calcifying tendinopathies occurring unilateral or bilateral and rarely causing associated clinical signs [6]. The most striking clinical symptom in insertion tendinopathy of the iliopsoas muscle is intermittent lameness of the hind limb, which is described as unilateral, bilateral, acute and chronic [2,4,7-9]. To the authors knowledge no further investigations about different shapes or possible changes of the lesser trochanter exist nor at which age changes may occur. Additionally, no possible associations with hip dysplasia or sex are evaluated.

The purpose of this study is to describe the morphology of the lesser trochanter in Rottweilers, German Shepherd Dogs and Bavarian Mountain Dogs. Moreover, the description of the radiographic appearance and frequency of possible enthesiopathies of the iliopsoas muscle at this level in those three breeds is reported. Additionally, possible associations between hip dysplasia and radiographic changes of the lesser trochanter have been examined.

### Materials and Methods

Six skeletally mature, canine cadavers and two macerated femora were radiographed to gain better understanding of the anatomy of the lesser trochanter prior to reevaluation of archived radiographs. Different positions were performed in order to improve visualization of this region. Three of those specimens received additional computed tomography (CT) examinations.

In total 736 ventrodorsal pelvic radiographs from Rottweilers (n=311, m=159, f=152), German Shepherd Dogs (GSD; n=133, m=76, f=54, fs=2, gender unknown=1) and Bavarian Mountain Hounds (BMH; n=292, m=137, f=151, gender unknown=4) were evaluated. Most radiographs were taken during routine examinations for canine hip dysplasia at the Division of Diagnostic Imaging of the University of Veterinary Medicine Vienna and therefore fulfilled the FCI standards in positioning. A German scrutinizer certified for evaluation of hip dysplasia provided the radiographs of most of the Bavarian Mountain Hounds.

Hip dysplasia was classified as grade A to E by a board certified radiologist (E.M.) or the before mentioned scrutinizer. Shape, size, surface, density and identifiability of the lesser trochanter were evaluated by one author (F.W.). When isolated bone opacities were present, they were evaluated in number, size, shape and surface. Possible accompanying soft tissue abnormalities (such as swelling or atrophy) were reported.

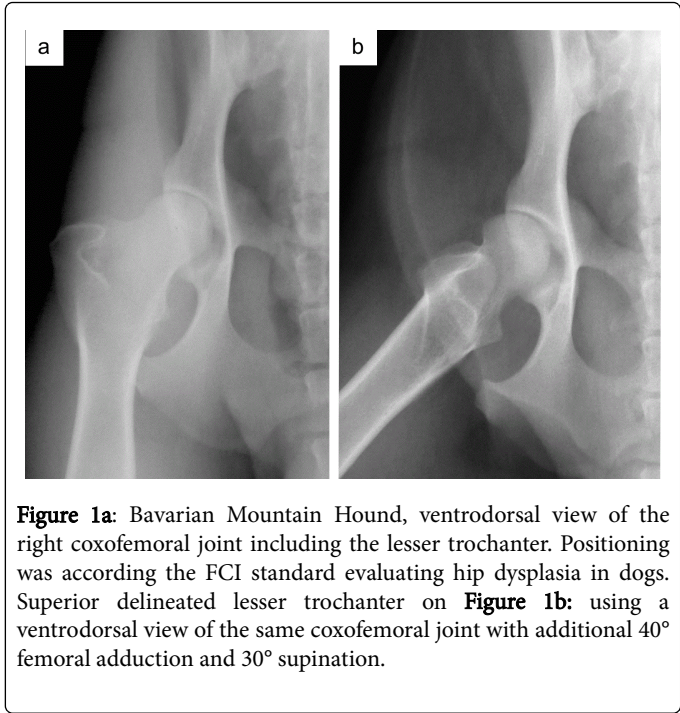
Additional computed tomography (CT) examinations (CT single slice 3rd generation, GE HiSpeed Dxi, GE Healthcare, Buckinghamshire, GB; 120 kVp, 80-130 mA, 2 seconds tube rotation time, 2 mm slice width and 2 mm sequential slice interval) including the region of the lesser trochanter were available in four skeletally mature Rottweilers and five German Shepherd Dogs. These dogs were presented as patients suffering from hind limb lameness and suspected lumbosacral instability. The lesser trochanter was evaluated the same way as radiographs, while the evaluation of the soft tissues was more accurate.

Statistical analysis was performed using Microsoft excel (Microsoft Corporation, Redmont, Washington, USA) and SPSS 14.0 (SPSS Inc., Chicago, USA).

Statistical evaluation was performed by Chi<sup>2</sup>-test. In cases where Chi<sup>2</sup>-test was not suitable due to small numbers in single cells, Fisher-Yates test was used.

Results

Radiographs of variable positioned dead mature canine specimens showed an optimal visualisation of the lesser trochanter in dorsal recumbency, with the femora supinated about 30° and abducted about 40° (Figures 1a and 1b). Nevertheless all lesser trochanters could be evaluated on the already existing radiographs positioned according the FCI standard evaluating hip dysplasia in dogs.

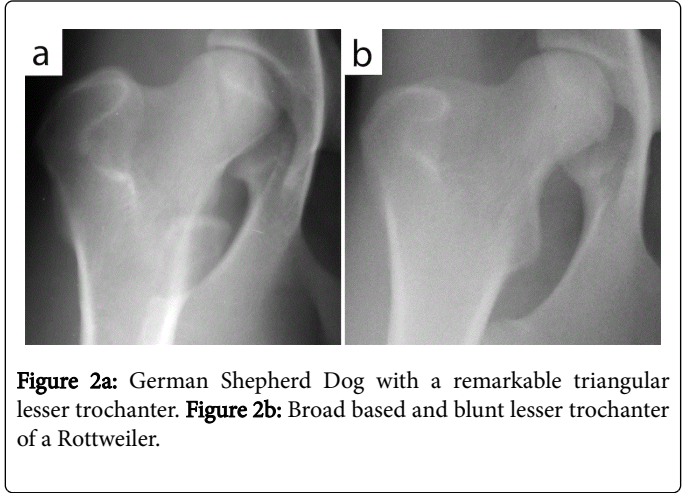


**Figure 1a:** Bavarian Mountain Hound, ventrodorsal view of the right coxofemoral joint including the lesser trochanter. Positioning was according the FCI standard evaluating hip dysplasia in dogs. Superior delineated lesser trochanter on **Figure 1b:** using a ventrodorsal view of the same coxofemoral joint with additional 40° femoral adduction and 30° supination.

The normal lesser trochanter appeared as a clearly defined bone protuberance of variable size on radiographs. It presented large and remarkable triangular in shape in German Shepherd Dogs, while it was rounded and broad based in Rottweilers and Bavarian Mountain Hounds (Figures 2a and 2b). Pathological findings or variations of the appearance of the lesser trochanter were classified in four categories as follows (Table 1).

In total 105/736 (14.27%) of the radiographic studies displayed variations of the lesser trochanter that could be categorized as follows.

25/736 (3.4%; 19 Rottweiler, 5 German Shepherd Dogs, 1 Bavarian Mountain Hound) animals showed a discrete blurring of the outer contour of the trochanter (category I, Figures 3a and 3b). Moderate to severe blurring as well as marked sclerosis (category II, Figures 3c and 3d) could be found in 28/736 of the radiographic studies (3.8%; 23 Rottweiler, 3 German Shepherd Dogs, 2 Bavarian Mountain Hounds). Isolated, well-delineated bone opacities proximomedially to the lesser trochanter indicated category III (Figures 3e and 3f) and were found in 45/736 of the radiographic studies (6.11%; 21 Rottweiler, 16 German Shepherd Dogs, 8 Bavarian Mountain Hounds). Category IV represented variations of the normal shape (Figures 4a, 4b and 4c). The lesser trochanter looked like a barn or a double-knuckle (“two-humped camel”) and was present in 7/736 animals (0.95%; 2 Rottweilers, 1 German Shepherd Dogs, 4 Bavarian Mountain Hounds). In 20 dogs (2.72%; 17 Rottweilers, 2 German Shepherd Dogs, 1 Bavarian Mountain Hound) at least two of the described changes were present in the same animal.



**Figure 2a:** German Shepherd Dog with a remarkable triangular lesser trochanter. **Figure 2b:** Broad based and blunt lesser trochanter of a Rottweiler.

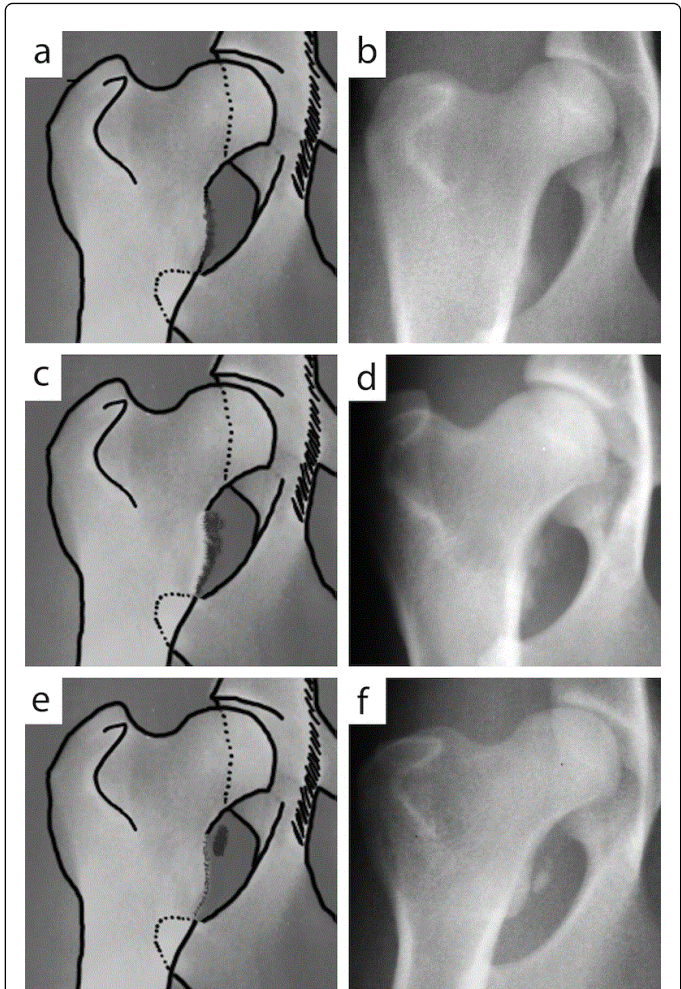
Category	Radiographic Findings
Category I	Discrete blurring of the outer contour of the lesser trochanter
Category II	Blurring and increased bone sclerosis of the lesser trochanter
Category III	Isolated bone opacities proximomedial to the lesser trochanter
Category IV	Variation of the shape of the lesser trochanter but clearly defined margins

**Table 1:** Categorisation of radiographic findings in lesser trochanters in Rottweilers, German Shepherd Dogs and Bavarian Mountain Hounds.

The few CT examinations supported the radiographic findings when compared to each other. Increased sclerosis of medullary cavity, thickening of cortical bone and blurring of outer contour were diagnosed in affected trochanters. Blurring of the lesser trochanter on radiographs is caused by periosteal reactions (Figures 5a and 5b). Additionally it was confirmed that the site of periosteal reactions resembled the insertion of the iliopsoas muscle. Therefore those blurring could already be addressed as enthesiopathies on radiographs. The course of the iliopsoas muscle at the region of insertion was clearly defined in CT when dogs were positioned in dorsal recumbency with coxofemoral joints in maximal flexed position (Figures 6a and 6b). Isolated bone attenuations like described in category III appeared with marked endosteal sclerosis in CT (Figures 5a and 5b). Neither in CT



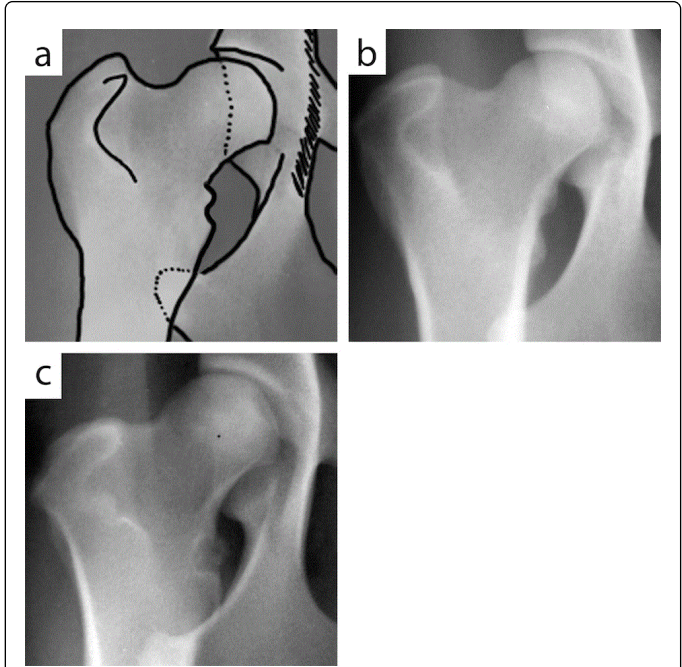
nor on the radiographic studies soft tissue changes such as altered attenuation (CT) or change of volume of the muscles (CT and radiographs) were present in affected side compared to the contralateral side.



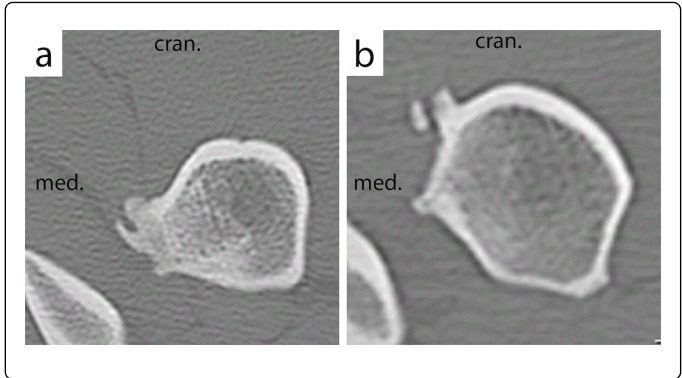
**Figure 3a:** Schematic drawing of category I variation: discretely blurred outer contour of the lesser trochanter. **Figure 3b:** Rottweiler with category I variation. **Figure 3c:** Schematic drawing of category II variation: severe blurring as well as marked sclerosis of the lesser trochanter. **Figure 3d:** Bavarian Mountain Hound with category II variation. **Figure 3e:** Schematic drawing of category III variation: Isolated bone opacity proximomedial to the lesser trochanter. **Figure 3f:** Bavarian Mountain Hound with category III variation.

Statistical analysis was used to assess possible associations between hip dysplasia and changes of the lesser trochanter. Hip dysplasia grade A and B were combined as “HD 1” (free of hip dysplasia) because those two grades are usually allowed to breed. All other grades were summarized to group “HD 2”, as they are excluded from breeding programs. A significant association between hip dysplasia and trochanter changes could be found in Rottweilers (n=278, p=0.02) and Bavarian Mountain Hounds (n=287, p=0.001), but not in German

Shepherd Dogs (n=124, p=0.102) (Table 2). Significant differences between the three breeds could be found with concern to the frequency of HD and changes of the lesser trochanter (Table 3).



**Figure 4a:** Schematic drawing of category IV variation: variation of the normal shape-double-knuckled lesser trochanter. **Figure 4b:** Bavarian Mountain Hound with category IV variation. **Figure 4c:** Rottweiler with double-knuckle shape, heterogeneity and sclerosis, indicating besides a variation of shape, a possible enthesiopathy.



**Figure 5a:** Transverse image of a femur of a Rottweiler (N°3/296) showing marked endosteal sclerosis as well as severe bony changes of the lesser trochanter indicating an enthesiopathy-bone window. **Figure 5b:** Transverse image of a femur of a Rottweiler (N°1/174) showing mild endosteal sclerosis as well as isolated bone attenuation in the iliopsoas muscle at the attachment site-bone window.

Breed	HD	Lesser trochanter	%	P (Chi <sup>2</sup> -test respectively Fisher-Yates test as appropriate)
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Rottweiler	HD 1 n=182	normal	90.10	0.020
		changes	9.90	
	HD 2 n=33	normal	75.76	
		changes	24.24	
German Shepherd Dog	HD 1 n=33	normal	100.00	0.102
		changes	0.00	
	HD 2 n=30	normal	90.00	
		changes	10.00	
Bavarian Mountain Hound	HD 1 n=207	normal	98.07	0.001
		changes	1.93	
	HD 2 n=75	normal	89.33	
		changes	10.67	

**Table 2:** Association of CHD grade and changes of the lesser trochanter. HD 1 represents canine hip dysplasia grade A and B (mostly acceptable for breeding), HD 2 represents canine hip dysplasia grade C, D and E (unacceptable for breeding).

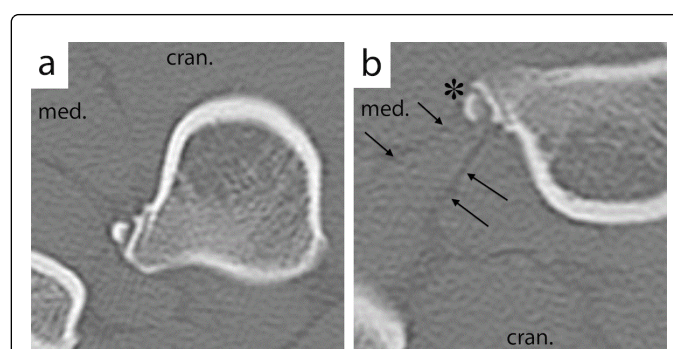
Breed	HD				lesser trochanter			
	HD 1		HD 2		normal		changes	
	n	%	n	%	n	%	n	%
Rottweiler	206	83.4	41	16.6	213	68.5	98	31.5
German Shepherd Dog	38	53.5 <sup>†</sup>	33	46.5	106	79.7 <sup>†</sup>	27	20.3
Bavarian Mountain Hound	215	73.6 <sup>‡</sup>	77	26.6	279	95.5 <sup>‡</sup>	13	4.5

**Table 3:** Breed differences in frequency of HD and changes of the lesser trochanter. As not in all cases information on both HD and lesser trochanter has been available the total numbers differ from that in Table 2 as well as between findings of HD and those of the lesser trochanter. <sup>†</sup>,<sup>‡</sup> Groups with different superscript differ with  $p < 0.001$ .

In 729/736 animals the gender was known, but no association between gender and trochanter anomalies was recognized ( $p=0.793$ ).

## Discussion

The iliopsoas muscle is the strongest of all sublumbar muscles and consists of two muscles: the psoas major and the iliacus [10]. Whilst the psoas major originates mostly at the transverse processes of L2 and L3 7;8 the iliacus originates on the ventral surface of the ilium [11]. The two muscles insert as a common tendon on the lesser trochanter of the femur. The iliopsoas muscle acts as a forward drawer of the pelvic limb by flexing the coxofemoral joint. Simultaneously, this muscle operates as a supinator of the stifle joint [10,12]. It is innervated by branches of the lumbar nerves and femoral nerve [11].



**Figure 6:** Dorsal recumbency, **Figure 6a:** elongated position and **Figure 6b:** flexed position: transverse images of an adult German Shepherd Dog showing an avulsion fracture of the lesser trochanter but no explicit endosteal sclerosis of the medullary cavity. Note the position of the bone fragment (asterisk) at the attachment site of the iliopsoas muscle (black arrows).

In the present study the lesser trochanter appeared radiographically with different shapes in different breeds. Interestingly, a broad based lesser trochanter is found in the muscular Rottweiler as well as in the slender and athletic Bavarian Mountain Hound while the trochanter of the German Shepherd Dog appeared radiographically triangular. The double-knuckle shape of the lesser trochanter could only be found in Rottweilers and Bavarian Mountain Hounds but not in the usually triangular shaped lesser trochanter of the German Shepherd Dogs. In human medicine a possible connection between muscle mass and skeletal appearance is discussed controversial. Benjamin et al. [13,14] state that a broad insertion region of tendons is responsible for the size of apophyses whilst Hamrick [15] argue that there is no influence or counteraction.

On the one hand the lesser trochanter in German Shepherd Dogs is taller than but not as broad as the lesser trochanter in Rottweilers.



Therefore the area of insertion seems to be smaller in the German Shepherd Dog. This finding was subjectively open to scrutiny on CT images, but no area calculations have been performed to confirm this finding on CT images. On the other hand the Bavarian Mountain Hound is a middle sized slender and wiry breed but has the broad lesser trochanter of the muscular Rottweiler. Another possible explanation for the peculiar shape of the lesser trochanter in the German Shepherd Dog is the breed characteristic of the lumbosacral region. Surprisingly two radiographs of two German Shepherd Dogs taken in 1962 and 1966 (when the dogs were still bred with a non-sloping lumbosacral spine) were available and displayed a similar shape of the lesser trochanter as today.

Different appearances of the lesser trochanter are classified in the present study. We assume that categories I to III are various degrees of enthesiopathies of the iliopsoas muscle while category IV represents an anatomical variation of the lesser trochanter. Unfortunately no study could be found that correlates radiographic findings and clinical relevance. In general enthesiopathies are diagnosed radiographically when marked sclerosis, blurring of the outer contour and bony spurs are present [16]. Therefore category IV seems to be interesting as it describes obvious variations of shape without further radiographic signs of enthesiopathy. The above described double-knuckle shaped trochanter may represent an anatomic variation of normal. On the other hand single dogs showed an inhomogeneous area between those two knuckles (Figure 3c), which would indicate pathology.

Bone opacities proximomedial to the lesser trochanter most likely represent avulsion fractures [5,17] as those bony shadows are always positioned within a muscle. Most of the radiographs had been taken for hip dysplasia screening. Therefore the dogs were 12 to 18 months old. According to literature [16] the growth plate of the lesser trochanter fuses between 8 and 13 months of age. This implicates that a possible trauma would have taken place in adolescence. The scenario of excited young playing dogs and therefore possible overloading of tendons is quite likely. Depending on the severity of the hypothesized trauma the changes appeared as discrete blurrings, variation in shape and size or opacities resembling most likely avulsion fractures or dystrophic calcifications of traumatized tendons.

Athletic injuries are the main reason of avulsion fractures in young human beings [18,19] with open growth plates. Possible muscular lesion without affection of the lesser trochanter in a 12 week old puppy was described [7]. Traumata affecting this region in adult dogs cause lesions of the iliopsoas muscle exclusively [1-3]. To the authors knowledge no study differentiates between psoas major and iliacus muscle.

It has to be mentioned that the present study describes the radiological findings mostly retrospective without further information about the clinical and orthopedically status. No animal of the present study was available for a pathohistological examination of the site of enthesis. Further data including force plates, clinical examination and kinematic data are needed to understand the mechanism and clinical relevance of these changes.

CT allowed a thorough evaluation of the anatomy studied and also reinforced radiographic findings. Especially mild blurring of the lesser trochanter and increased sclerosis of the medullary femoral cavity were confirmed as radiographic signs of enthesiopathy in CT. Very discreet findings were visible in CT only. Endosteal sclerosis of an affected lesser trochanter resembled those changes found in fractured medial coronoid process of the ulna. Category III changes seemed to resemble

similar fragments as described in a case report [4]. In CT additionally the diameter as well as the course of single muscles, especially iliopsoas muscle, could be observed. Therefore changes at the lesser trochanter could be certainly assigned to originate from the iliopsoas muscle. It has to be stressed that the muscle is more easily visualized in CT using dorsal recumbency and flexed coxofemoral joints.

In general evaluation of the lesser trochanter is feasible on radiographs whilst screening hip dysplasia. In suspicious cases an additional view with supinated (30°) and abducted (40°) femora would be recommended.

Sonography would enable further evaluation of the iliopsoas muscle without anaesthesia. The ultrasonographic evaluation of the normal iliopsoas muscle including the common insertion is described [20]. With muscular lesions it is described to be thickened and hypoechoic [3,21,22]. Avulsion fractures within a tendon cause hyperechoic areas with associated distal acoustic shadowing [23] and retraction of the tendon from its fragment bed [24]. The bone margin presents irregular at the avulsion site [25]. MRI is superior to CT in displaying soft tissue changes. To the authors knowledge it has been used in single cases of an iliopsoas myositis [26] cases of iliopsoas abscess [27,28], a fibrotic myopathy [29], a primary hemangiosarcoma of the iliopsoas muscle [30], and a femoral neuropathy in a dog with iliopsoas muscle injury [8].

According to the statistical findings no association could be found between gender and affected lesser trochanter. In literature [31] potential connection between increased estrogen levels and laxity of tendons and joints is discussed. In the present study the gender and therefore the hormone status has no effect although the examined bitches should already have experienced their first heat.

Only few Bavarian Mountain Hounds showed radiographically changes of the lesser trochanter although this breed suffers a relatively high percentage of HD. In Bavarian Mountain Hounds and Rottweilers a significant association with hip dysplasia could be found statistically. Nevertheless, it cannot be proved that hip dysplasia grade is influenced by lesions of the lesser trochanter or the iliopsoas muscle. It has been not studied if the side of the lesser trochanter findings corresponded to degenerative changes of the ipsilateral coxofemoral joint.

## Conclusion

The results of this study offer a possible new aspect in evaluating working and sports dogs imaging wise, as enthesiopathies of the iliopsoas muscle occur in adolescent dogs and might act as a life-long weak point. Further studies, especially measurements of ground-reaction-forces on a treadmill in such dogs could provide more information about a possible interference and to assess clinical relevance.

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